J. Agron. Indonesia 39 (2) : 79 - 84 (2011)

Application of Filter Cake on Growth of Upland Sugarcanes

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Received 22 December 2010/Accepted 25 May 2011

ABSTRACT

Recently planting site of sugarcane was shifted from lowland to upland area. Sugar cane cultivation in upland has many constraints, especially limited water supply and low nutrition availability. The objectives of this research were to study the influence of application of composted filter cake on growth and water use efficiency of upland sugar cane. The research was conducted in Jengkol, Kediri. Treatments consist of three factors: frequency of irrigation (once every 1 week, once every 2 weeks, and once every 3 weeks); sugarcane varieties (PS-862 and PS-864); and compost doses (0, 2.5, 5, and 7.5 ton ha^{-1}). Split plot design with three replications was used in each irrigation treatment, using composted filter cake as main plots and sugarcane varieties as sub plots. The results showed that the highest sugar content was reached at application of 5 ton ha^{-1} compost and the greatest crystal sugar was reached at 3.09 ton ha^{-1} compost. Compost application at 5 ton ha^{-1} on each planted row can reduce frequency of irrigation from once a week to once every 2 weeks.

Keywords: compost of filter cake, frequency of irrigation, upland sugar cane

ABSTRAK

Saat ini areal pengusahaan tebu bergeser dari lahan sawah ke lahan kering. Budidaya tebu di lahan kering banyak mengalami kendala, terutama dari pasokan air dan ketersediaan hara tanah. Penelitian ini dilakasanakan dengan tujuan mempelajari pengaruh pemberian kompos blotong terhadap pertumbuhan dan hasil tebu di lahan kering serta efisiensi penggunaan air. Penelitian terdiri tiga faktor perlakuan, yaitu frekuensi pemberian air (tiap minggu, 2 minggu sekali dan 3 minggu sekali); varietas tebu (PS-862 dan PS-864); dan dosis kompos blotong (0, 2.5, 5.0, dan 7.5 ton ha^{-1}). Digunakan rancangan petak terpisah (split plot design) dengan tiga ulangan pada tiap perlakuan frekuensi penyiraman. Hasil penelitian menunjukkan bahwa rendemen tebu tertinggi dicapai pada perlakuan kompos 5 ton ha^{-1} dan hasil hablur gula tertinggi dicapai pada dosis kompos 3.09 ton ha^{-1}. Pemberian kompos blotong 5 ton ha^{-1} pada juringan tanaman mampu mengurangi frekuensi pemberian air dari tiap minggu menjadi 2 minggu sekali.

Kata kunci: kompos blotong, efisiensi penggunaan air, hablur

INTRODUCTION

Sugar industry is one of the agricultural industries that relies on integrated managements of agribusiness and agroindustry. Indonesia was once a major sugar exporter in the world, but has turned into one of the biggest sugar importers. The sugar consumption in 2010 was 4.6 million tonnes, consisted of 2.4 tonnes of household consumption and 2.2 tonnes for food and beverages industry. The current production of white sugar crystals from sugarcane in Indonesia is 2.3 million tonnes (Indonesian Sugar Association, 2011). The main cause of the low productivity of sugar in Indonesia is low rendement. The rendement data obtained from most sugar factories in Indonesia for the last 10 years is 6.5-7% (IAARD, 2005; Mardianto *et. al.*, 2005)

Most of the sugarcanes in Indonesia (77%) are grown in upland. The total production area is ± 430,000 ha, which consist of 270,000 ha in Java island and 160,000 ha outside Java (Indonesian Sugar Association, 2011). Upland farming is a cultivation of plants without irrigation (Gupta, 1995). Upland farmings rely on conservation and use of water stored in the soil and on rain water (Whitty and Chambliss, 2002). Therefore, in is important to increase water use efficiency in sugarcane grown on upland (Desai, 2000).

Low soil water availability and low fertility, particularly in phosphorus and soil organic matters, are some of the limitations of upland farming. The organic matter content in soil around sugar factories in East Java is less than 3%, whereas the optimum level of soil organic matter for sugarcane should not be less than 5% (Karama, 2000). Low soil organic matter content reduced fertilizer use efficiency as well as soil water retention capacity (Inman-Bamber and Smith, 2005).

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Sugarcane needs good water supply particularly during early growth, and needs less water during maturity periods. Sugarcane growth normally stops at the beginning of dry season and then reaches the generative stages (Barnes, 1974).

The formation of monosacharides occurs when plants are 4-months old, whereas sucrose formation occurs at the start of dry season, triggered by sucrose phosphate synthase enzymes (Lehninger, 1982; Babb and Haigher, 2001). The water availability during the early stage of plant growth is an important factor to ensure the subsequent sugarcane growth (Meady and Chen, 1977). Water shortage during the early stage will reduce early plant growth and will have negative effects on sugar formation (Ana, 1999). Therefore it is critical to supply water to sugarcane plants during their early stage of development. The water requirement for sugarcane early growth was reported to be equivalent to rainfall of 100 mm month^{-1}. On the other hand, drier condition during the end of the growing period is preferable to allow better formation of sucrose and sugarcane ripening.

Several studies have confirmed that water availability for sugarcane early growth has positive impacts on their subsequent growth (Desai, 2000). However, the exact amount and the timing of watering have not been well understood. Sugarcanes grown upland needs extensive watering, or alternatively drought tolerant varieties could be used (Prasetyo and Suriadikarta, 2006).Water usage efficiency depends on the soil type, soil physical properties, and the amount of organic matters in the soil (Antwerpen and Meyer, 2003). One of the organic matter source is sugarcane filter cake, or *blotong*, i.e. by-products of sugarcane after the sugarcane has been processed for the manufacture of sugar. The amount of filter cake produced as by-products from sugar processing range from 4-5% of the total sugarcane fresh weight (PG Gunung Madu Plantation, 1999).

The use of filter cake in sugarcane plantation has been increasing. Suhadi and Sumojo (1985) reported that filter cake application increased soil water holding capacity, and Utomo and Susanti (1986) reported that filter cake application to sugarcane grown on uplands in South of Malang, East Java, increased yield by 25%. Furthermore, Toharisman *et al*. (1991) reported that filter cake application increased the availability of soil P and Ca for plants grown on dry lands. However, the effects were not significant on wetland alluvial soil.

High water content in unfermented filter cake makes its application to soil difficult to do. Filter cake have to be composted before applying them to the soil. Addition of composted filter cake to marginal land (S3) in Lamongan increased sugarcane yield by 15% compared to untreated soil (Siswanto, 1998). Whereas application of composted filter cake and bagasse were reported to improve nutrients absorption, particularly N and S, and to increase sugarcane growth in dry land. Study conducted on heavy soils at PG Jatitujuh demonstrated that application of filter cake increased availability of P and K at the end of growing periods (Guntoro *et al.*, 2003).

These research were conducted to determine methods of increasing water use efficiency and to increase sugar yields from sugarcanes grown in dry land. The specific objectives were to study the effect of application of composted filter cake on growth, yield and rendement of sugarcane grown in dry land.

MATERIALS AND METHODS

Experiments were conducted in research experimental station at PTPN X, Jengkol Kediri during August 2006 to September 2007. The experiments used three treatments, i.e. watering frequency (once every one week, once every two weeks, and once every three weeks, using 80 L of water per furrow); sugarcane varieties (PS-862 and PS-864), and doses of composted filter cake (0, 2.5, 5 and 7.5 ton ha^{-1}).

In each watering frequency treatment, the experiment was arranged in a split plot design, using composted filter cake as main plots and sugarcane varieties as sub plots (Gomez and Gomez,1984). Data was analyzed using ANOVA, followed by Tukey's HSD. The effects of compost doses were be further tested using regression analysis.

Composted filter cake were obtained from Research and Development Unit of the PTPN X. Chemical fertilizers of ZA, SP-36, and KCl were used. Sugarcane were planted using 'juringan' or furrow system , i.e. length of 8 m, 0.45 m width and distance between furrow centres of 1.1 m. Every experimental unit consists of 5 furrows. Three-eyes cuttings from Jengkol nursery at Litbang PTPN X were used as planting materials. Every meter of furrow have 9 eyes or 3 cuttings, therefore each furrow have 72 eyes. The plants were fertilized with 700 kg ZA, 200 kg SP-36, and 200 kg KCl. ZA was applied twice, at planting and at 3 months old after planting. SP-36 fertilizer was applied once at planting, whereas KCl was applied at 1 month and 3 months after planting.

Composted filter cake was applied at 1 week before planting by spreading evenly at the base of each furrow. Furrows were watered manually to field capacity using watering can at 100 m^3 ha^{-1} atau 80 L each *juring*.

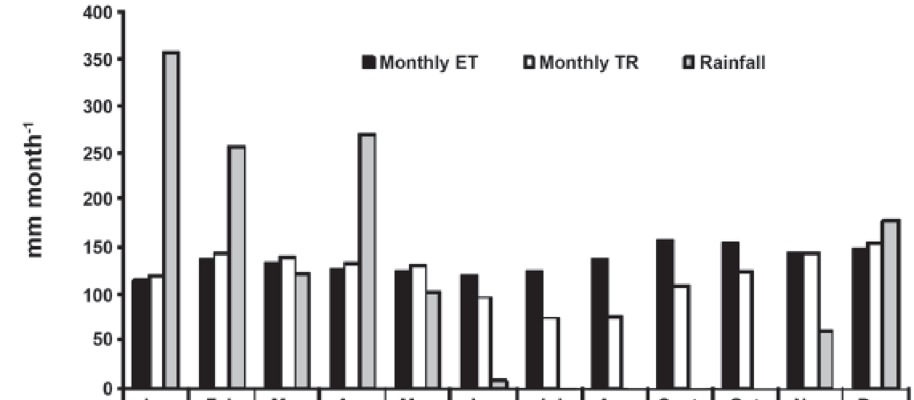
Measurements were made on plant height, number of buds per meter of furrow, leaf area, leaf curve (measured from leaf axil to the curved point), number of canes per meter of furrow, cane diameter, cane length, number of total canes and harvestable canes, cane weight per m, brix, and pol in the sugarcane juice, sugar content (rendement) and sugar yields. Rendement was calculated using formula by Meady and Chen (1977).

RESULTS AND DISCUSSION

Rainfall and Soil Water Content

Dry months in the year of 2006 and 2007 occurred during May to September and June to early October, respectively (Figure 1). Period between June to August is a good time to plant sugarcane to produce high rendement, but the plants will need supplementary irrigation for at least three months.

The soil in the experimental station is sandy loam and is classified as Regosol (ISRI, 2005). The organic matter



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Monthly ET	114.3	136.5	132.9	125.1	123.3	120.0	123.3	137.7	155.1	154.5	143.4	146.1
Monthly TR	120.0	143.3	139.5	131.4	129.5	96.0	74.0	75.7	108.6	123.6	143.4	153.4
Rainfall	357.0	256.0	122.0	270.0	101.0	7.0	0.0	0.0	0.0	0.0	59.0	178.0

Figure 1. Rainfall, potential evapotranspiration (TR) and plants evapotranspiration (ET) in the year of 2006

and nitrogen levels in this soil were relatively low. Soil pH was 6.7 and soil has a relatively high contents of P and K, i.e. 75 ppm dan 83 mg 100 g^{-1}, respectively.

Potential evapotranspiration during the experiment were 130-150 mm month^{-1}, whereas the the actual evapotranspiration were 75-100 mm month^{-1} if k-value of the plants are taken into acount. Evapotranspiration in August, September and October were lower than its potential evapotranspiration. The soil water is the only water source for evapotranspiration during those dry and no-rain periods.

Soil water content fluctuated according to the watering frequency of once, twice and three times a week (Figure 2). Soil applied with 7.5 ton ha^{-1} of composted filter cake had a higher water content compared to other treatments. This results demonstrated that soil added with composted filter cake resulted in a better water retaining properties. The water content of soil watered once a week increased quite significantly, followed by a decreased to soil water content of 24%. The water content of soil watered every two or three weeks increased slightly, followed by a decrease to 15% before rewatering. However, the plants this treatment have not started wilting. The ability of soil to supply water to plants depend on soil types. Soils with a finer structure in the deeper layer usually have a better water retaining properties. Therefore the plants usually survived even though the soil water content had reached a very low level (Antwerpen and Meyer, 2003).

Sugarcane Growth

Plant height and cane diameter were not affected by watering frequency, doses of compost, and plant varieties (Table 1). Leaf curvatures of all treatments were similar at one month after planting, but started to show differences after 3 months. Plants watered weekly had shorter curves, indicating that the plants did not experience water shortage. Plants exposed to drought usually had erect leaves.

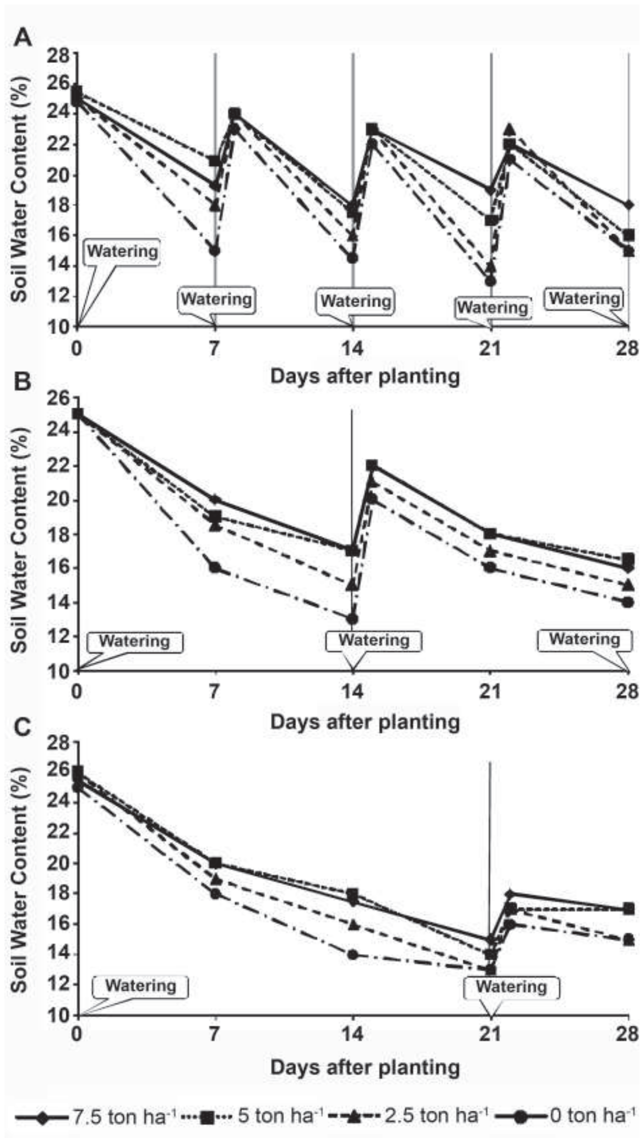


Figure 2. Soil water content at (a) watering once a week; (b) watering every two weeks; (c) watering every three weeks

Table 1. Watering frequency and plant height, tiller number, cane diameter at 6 MAP, and leaf curvatures at 1 and 3 MAP

Watering frequency	Plant height (cm)	Tiller number	Cane diameter (cm)	Leaf curvatures 1 MAP	Leaf curvatures 3 MAP
Weekly	228.4	138.4a	2.78	30.5	64.6b
Every two weeks	224.8	155.8b	2.86	31.4	68.5a
Every three weeks	223.6	130.5c	2.81	30.1	67.7ab

Note: Values followed by same letters within a column are not significantly different at 5% HSD; MAP = month after planting

Watering frequency significantly affected the number of tillers. Plants watered every two weeks had a greatest number of tillers. Cane diameter differs with sugarcane varieties and were not affected by watering frequency or doses of compost. PS 862 has been described as genetically have large cane diameter. In this experiment the cane diameter of PS 862 were significantly larger than those of other varieties.

Cane Yield and Rendement

Doses of compost siginificantly affected brix, pol value of sugarcane extracts, rendement potential, and rendement of sugarcane (Table 2). Watering frequency and sugarcane varieties affected the number of canes per meter of furrow, but did not affect other variables (Table 3). Watering frequency interacted with compost doses in affecting sugarcane rendement. There were no significant interactions between the other the treatments. Watering every two or three weeks reduced the number of canes per meter of furrow compared to watering weekly. Positive correlations were found between Brix, pol, and rendement. Brix correlated positively with pol (0.64); higher Brix will be followed by a higher pol values. Similarly, Pol and rendement correlated positively (0.65); higher pol will be followed by a higher rendement. There were significant correlations between

Table 2. Compost doses and brix, pol, purity, rendement potential, and rendement of sugarcane

Compost doses (ton ha^{-1})	Brix (%)	Pol (%)	Purity (%)	Rendement potential (%)	Rendement (%)
0.0	18.87b	14.52ab	77.15	9.04ab	7.68a
2.5	19.22ab	14.90a	77.64	9.06a	7.70a
5.0	19.28a	14.86a	77.19	9.10a	7.73a
7.5	18.95ab	14.20b	74.99	8.42b	7.16b

Note: Values followed by same letters within a column are not significantly different at 5% HSD

Table 3. The effect of watering frequencies, varieties and doses of compost on cane numbers, cane length at harvest, cane fresh weight, yield and crystal sugar yield

Treatments	Number of cane	Cane length (cm)	Cane fresh weight (kg m^{-1})	Yield (kg $plot^{-1}$)	Yield (kg ha^{-1})	Crystal sugar (kg ha^{-1})
Watering frequency						
Weekly	7.5a	298.83a	0.72a	532a	95,57a	7,245a
Every two weeks	6.2b	299.71a	0.70a	531a	95,55a	7,266a
Every three weeks	6.0c	299.00a	0.71a	529a	95,51a	7,236a
Variety						
PS862	6.6a	300.03a	0.74a	530a	95,43a	7,243a
PS864	6.6a	298.33a	0.68b	530a	95,48a	7,209a
Compost doses (ton ha^{-1})						
0.0	6.5a	301.06a	0.683b	529a	95,22a	7,313ab
2.5	6.6a	298.78a	0.710ab	524a	94,28a	7,26ab
5.0	6.6a	301.50a	0.721a	559a	100,67a	7,782a
7.5	6.6a	295.39a	0.717a	509a	91,65a	6,562b

Note: Values followed by same letters within a column are not significantly different at 5% HSD brix and sugar yields, and the sugarcane juice content has a major contribution to sugar yields.

Increasing compost doses to 5 ton ha^{-1} increased the rendement, but increasing it to 7.5 ton ha^{-1} resulted in a decreased rendement. This decrease might be related to the decrease in plant growth due to nitrogen immobilisation by decomposition of the filter cake. Rendement is the ratio of sucroses to sugarcane fresh weight. Sucrose formation is related to formation of glucose and fructose monosacharides. The metabolisms of these two monosacharides are influenced by plant health and plant growth. Disturbances in plant's early growth might result in disruption of the formation of these two sugars, which might explain the decrease of rendement from plants treated with 7.5 ton ha^{-1} compost (Singels *et al*., 2005).

Yield is calculated from numbers of canes, cane length, and cane fresh weight per meter. A greater cane fresh weight per meter of plants received a higher dose of compost did not result in a greater yields, since their cane length and number of canes were similar to those from other treatments. Therefore an increase in cane fresh weight per meter alone did not necessarily increase yield per hectare.

Watering frequency interacted with compost doses. The highest rendement was achieved by plants watered every two weeks and applied with 5 ton ha^{-1} of compost (Table 4). Reducing of watering from once a week into once in two weeks is beneficial for the farmers since it will significantly reduce the costs for water pumping as well as for labours (Cahyanti *et al*., 2008).

Compost application resulted in a higher crystal sugar yields, which is the main purpose of growing sugarcanes. Crystal sugar yield is calculated based on cane fresh weight per ha and their rendement. The regression equation for crystal sugar yield vs compost doses is $y = 7{,}197{,}2 + 280{,}86\,x - 46.68\,x^2$, with $R^2 = 0.65$ (Figure 3). The highest crystal sugar yield of 7,620 kg ha^{-1} was achieved at compost dose of 3.01 ton ha^{-1} (Figure 3). Previous studies have demonstrated that external environmental factors greatly influenced the final rendement. Optimum growing condition during sugarcane early growth is critical to ensure high sugar yields (Singh *et al*., 2003). Less growth during less optimum condition will be compensated by fast growth during favourable environmental conditions, but this delayed growth might delay or disrupt sugar formation (Singels *et al*., 2005).

Table 4. The effect of watering frequency and filter cake compost doses on sugarcane rendement

Compost doses (ton ha^{-1})	Watering frequency		
	Weekly	Every 2 weeks	Every 3 weeks
	..............................%		
0.0	7.54a	7.77bc	7.74b
2.5	7.91b	7.45ab	7.75b
5.0	7.81b	8.00c	7.39a
7.5	7.34b	7.04ab	7.10a

Note: Values followed by same letters within a column are not significantly different at 5% HSD

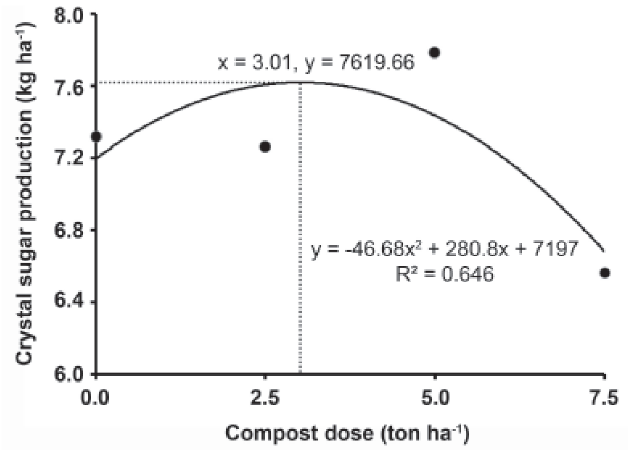


Figure 3. Correlations between compost doses and crystal sugar yield ha^{-1}

CONCLUSIONS

Sugarcane varieties responded similarly to watering frequency treatments. Watering the plants weekly at 80 L of water per 8 m of furrow, or equivalent to 100 m^3 of water per hectare did not increase crystal sugar yield per hectare compared to watering every two or three weeks. The highest rendement was achieved if plants were treated with 5 ton ha^{-1} of compost, whereas the greatest crystal sugar yield (7.620 kg ha^{-1}) was achieved at 3.01 ton ha^{-1} of compost. Therefore, application of compost at 5 ton ha^{-1} can reduce watering frequency to every two weeks.

Application of filter cake compost at 3-5 ton ha^{-1} are recommended for upland sugarcane planting in order to reduce watering frequency. The amount of compost applied should be in quantities that can increase soil organic content of around 3%, and compost should be applied regularly to maintain the 3% level in the soil. Due to the limited amount of filter cake produced by sugar factories, application of filter cake should be prioritized to areas which has soil organic content of < 3% since these areas are likely to be prone to drought, or to areas with growing season between July to September each year.

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